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16. Abstract

The Texas Central Partners are in the process of developing a high speed rail line connecting Houston and Dallas, Texas. Ultimately, plans are for 8 car trains that accommodate 200 people per vehicle scheduled every 30 minutes. In addition, Texas Department of Transportation (TxDOT) and officials in Austin, Houston and San Antonio are investigating intercity (interregional) rail to provide frequent rail service linking those cities. After arriving, passengers will need disbursement throughout the cities from the rail terminal station. The menu of options includes passenger pick-up (private by a friend or relative or purchased through a provider), taxi/limousine, rental car or public transportation. This research investigates the distribution patterns of northeastern cities with a history of intercity ground transportation as well as distribution patterns from a Houston area airport to assess the potential modal choices of passengers disembarking from intercity rail systems in Texas. In addition, a gravity formula is applied to several employment/activity locations to anticipate patrons' distribution choices. The research focuses on the proposed location for the high speed rail terminal.

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High Speed Rail Distribution Study

by

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Southwest Region University Transportation Center

with

Houston Galveston Area Council
Uptown Houston Association
Central Houston Improvement District

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EXECUTIVE SUMMARY

The Texas Central Partners (TC) are in the process of developing a high speed rail line connecting Houston and Dallas, Texas. Ultimately, plans are for 8 car trains that accommodate 200 people per vehicle scheduled every 30 minutes during rush hours and less frequently during mid-day. In addition, Texas Department of Transportation (TxDOT) and officials in Austin, Houston and San Antonio are investigating intercity rail, also called interregional rail, to provide frequent rail service linking those cities. After arriving, passengers will need disbursement throughout the cities from the rail terminal station. The menu of options includes passenger pick-up (personal by a friend or relative or purchased from a provider), taxi/limousine, rental car or public transportation.

Rail corridors, notably along the east coast have served intercity commuters for decades, key among them, the Boston, New York to Washington, DC corridor served by Amtrak. Lessons may be learned from these cities and also from intercity commuting corridors between cities in California in terms of efficiently connecting rail commuters to ground transportation. Previous US DOT studies showed five states with other modes meeting intercity rail systems at some stations and five additional states, where intercity rail connections may be made with other modes at all stations.

Critical to the Houston area success of the rail linking Dallas and Houston is the connections from the terminal station, currently proposed for roughly the intersection of IH-10/Old Katy Road. The methodology to assess the distribution began with investigation of the distribution patterns of northeastern cities with a history of intercity ground transportation as well as distribution patterns from a Houston area airport to anticipate mode split of passengers disembarking from intercity rail systems in Texas. Also, a gravity based equation was employed to show the relative attraction of several employment centers.

First Mile/Last mile is a term used in transportation to describe the movement of people and goods from a terminal or station location to the ultimate intended destination. In this paper, purchased personal transportation is termed Transportation Network Companies (TNC) and refers to scheduled pick up with the reservation made via a mobile application or website (eg., Uber, Lyft, Via).

Findings from this work are designed to assist in guiding area officials in assessing physical needs, such as vehicle bays, rental facilities, passenger pick-up areas to meet the anticipated disbursement of TC passengers. While there are no direct comparisons from other US cities with intercity rail or the Houston airports, the work allows several general thoughts.

- Transit users will likely be destined to Uptown and Downtown, particularly so as those connections are anticipated to be improved with the implementation of high speed rail. In fact, the transit travel time in future years may be better than personal vehicle travel time to these two locations.
- High speed rail patrons destined to other activity centers may choose transit, but are less likely to do so than those destined to Uptown and Downtown.
- High speed rail patrons destined to non-activity centers are most likely to use TNCs, other personal vehicle modes, or rental car.
- Taxi will likely be a prominent choice and should be well-accommodated
- It is important to ensure covered, protected amenities for all connections.
- Bicycle accommodations should be provided.

TABLE OF CONTENTS

Page

1. BACKGROUND 1

2. THE HIGH SPEED RAIL LINE 2

Description 2

Connectivity 3

3. METHODOLOGY 5

Survey Gathering 5

Gravity Model 5

4. FINDINGS 7

Survey Findings 7

Airport Select Modal Egress 7

Gravity Equation 8

5. SUMMARY OF FINDINGS 10

REFERENCES 11

APPENDIX 12

LIST OF TABLES

Page

Table 1: Explanation of Variables 6

Table 2: Taxi, TNC and Limousine Usage from Houston Airports 8

Table 3: Summary of Gravity Index, Transit Travel Time and Distribution Options 9

LIST OF FIGURES

Page

Figure 1: Image of HSR Vehicle 2

Figure 2: HSR Route Options 2

Figure 3: Percent of Mega Commuters Rapino and Fields (2013) 3

Figure 4: Box A: Connectivity on the Coasts 3

Figure 5: Proposed terminal location near IH10 and Old Katy Road 4

1. BACKGROUND

The Texas Central Partners (TC) are in the process of developing a high speed rail line connecting Houston and Dallas, Texas. Ultimately, plans are for 8 car trains that accommodate 200 people per vehicle scheduled every 30 minutes during rush hours and less frequently during mid-day. In addition, Texas Department of Transportation (TxDOT) and officials in Austin, Houston and San Antonio are investigating intercity rail, also called interregional rail, to provide frequent rail service linking those cities. After arriving, passengers will need disbursement throughout the cities from the rail terminal station. The menu of options includes passenger pick-up, taxi/limousine, rental car or public transportation. This research investigates the distribution patterns of northeastern cities with a history of intercity ground transportation as well as distribution patterns from a Houston area airport to anticipate mode split of passengers disembarking from intercity rail systems in Texas. Lastly, a gravity based equation is employed to show the relative attraction of several employment centers from the TC preferred terminus near the intersection of IH 610 and US 290. Findings from this from this work are designed to:

- Assist in guiding area officials in beginning to assess physical needs, such as vehicle bays, rental facilities, passenger pick-up areas to meet the anticipated disbursement of TC passengers
- Provide information for public and private transportation entities to anticipate how they might prepare for interregional rail and interconnectivity with their operation.

Because there is no existing frequent interregional rail service in Texas, knowledge about expectations on this subject is lacking. Important to the ultimate demand is the quality and location of the intermodal terminal and intermodal connections. A 2007 nationwide study by Goldberg shows that bus is the most frequent vehicle for connecting intermodal services in the northeast corridor and bus must be viewed as a vital component. The Goldberg study found that a number of Amtrak rail stations are served by Amtrak Thruway, the company's intercity bus feeder network. Also important is that travel transfers across modes must be timely and convenient. Patrons must feel safe and the connecting walk must be pleasant and interesting. Connectivity criteria are established by US Bureau of Transportation Statistics and will be delineated as part of this study (Goldberg, 2009).

Clearly, the public transportation and land patterns in Texas cities are unlike those in the nation's northeast corridor. Therefore, studying disbursements from inner city airports such as Hobby and Love Field could contribute to gaining insight about passenger distribution from high speed rail.

2. THE HIGH SPEED RAIL LINE

Description

The cities of Houston, Dallas, Austin and San Antonio form the core of the Texas megaregion termed the Texas Triangle. Connections between the megaregion cities in Texas are important for economic vitality. Transportation linkages must be for freight and passengers. Passenger rail connecting the cities is beginning through an approximately 240 mile high speed rail line proposed between Houston and Dallas by Texas Central Partners (TC) (Figures 1 and 2).

Figure 1: Image of HSR Vehicle
http://www.texascentral.com/project

Figure 2: HSR Route Options
http://www.texascentral.com/alignment - maps

One phenomenon of the past several decades is a change in how Americans view their work trip. As residences and jobs moved further from the urban core, commute trip lengths increased showing that people are willing to live great distances from their jobs. The ultimate example of this acceptance is persons who commute between cities. Texas cities are shown on a national map of mega commuters, those traveling more than 90 minutes and 50 miles (Figure 3). While we cannot see the actual commute pairs underlying the graphic, Texas' megaregions of Houston, Dallas metroplex, San Antonio and Austin are observable. Global Workplace Analytics' analysis from the American Community Survey indicates that the number of people, who are not self-employed and work at home incresed103% since 2005, and roughly 50% of the population works at home at least part of a week. According to TC, approximately 50,000 people travel between Houston and Dallas/Fort Worth multiple times per week.

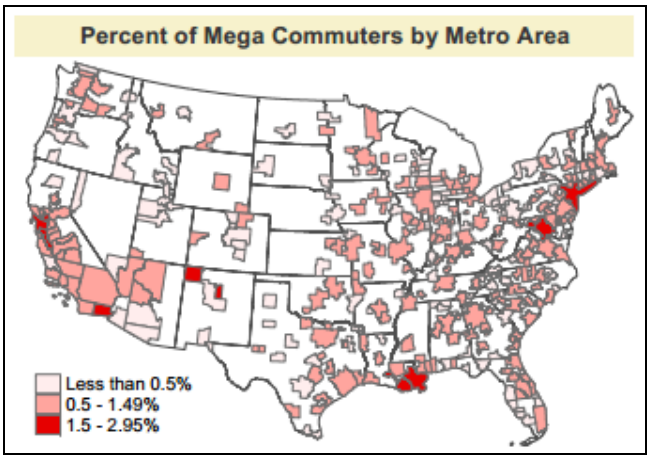

Figure 3: Percent of Mega Commuters Rapino and Fields (2013)

Connectivity

Rail corridors, notably along the east coast have served intercity commuters for decades, key among them, the Boston, New York to Washington, DC corridor served by Amtrak. Lessons may be learned from these cities and also from intercity commuting corridors between cities in California in terms of efficiently connecting rail commuters to ground transportation. A US DOT Rita Commissioned study (2007) showed five states with other modes meeting intercity rail systems at some stations and five additional states, where intercity rail connections may be made with other modes at all stations. The states are listed in Figure 4. The objective is for a smooth functioning trip end to the final desired destination, not just to the rail terminal.

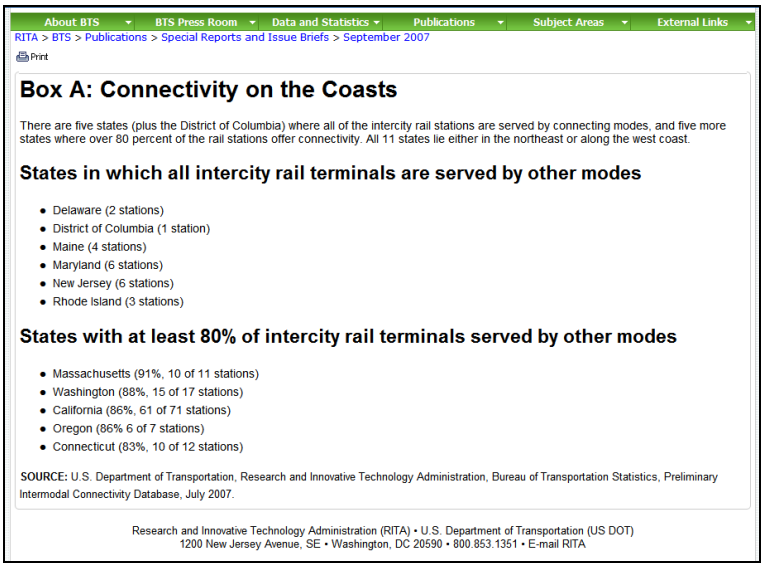

Figure 4: Box A: Connectivity on the Coasts

http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/special_reports_and_issue_briefs/special_report/2007_09_18/html/box_a.html

Critical to success of the rail linking Dallas and Houston is the connections from the terminal station, currently proposed for roughly the intersection of IH-10/Old Katy Road (Figure 5). In transportation vernacular, this type of connection is known as *first mile/last mile*. First mile/last mile is a term used in transportation to describe the movement of people and goods from a terminal or station location to the ultimate intended destination. A number of modal choices are available for the connections – transit, taxi/limousine, jitney, personal or purchased passenger pick-up, bicycle, and rental car. In this paper, purchased personal transportation is termed Transportation Network Companies (TNC) and refers to scheduled pick up with the reservation made via a mobile application or website (eg., Uber, Lyft, Via).

The IH-10/Old Katy Road area is currently underdeveloped and houses a number of warehouses and low density commercial uses. There is also vacant property that will be attractive for higher density transit supportive land uses.

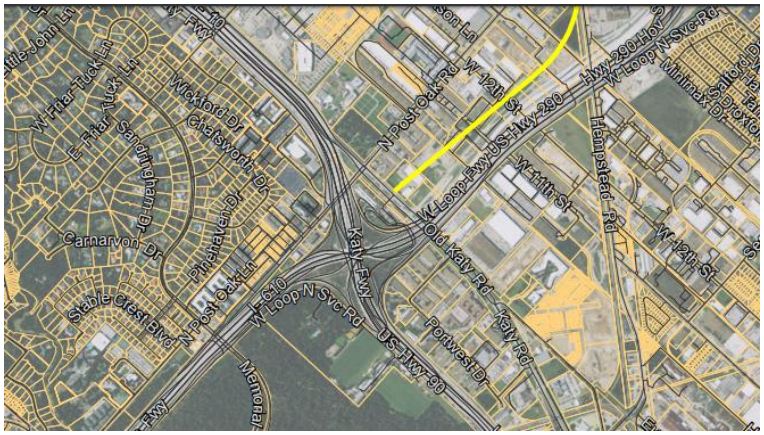

Figure 5: Proposed terminal location near IH10 and Old Katy Road
http://www.texascentral.com/alignment - maps

3. METHODOLOGY

There are three components of the methodology: First a survey of cities with intercity rail was conducted. Secondly, a representative from Houston Hobby and Bush Intercontinental Airports sent information regarding several egress modes. The third component entailed implementation of a transportation gravity model. Additional detail for the survey gathering and gravity model follow.

Survey Gathering

The team solicited information from cities with intercity rail connections. Surveys were forwarded to 20 agencies (listed in the Appendix), followed by email and telephone requests for response**.** Six agencies responded as shown.

- METROlink – Southern California
- NM Rail Runner – Santa Fe to Belen, NM
- VRE – Virginia Railway Express
- MBTA – Boston, MA
- Sounder – Lakewood, Tacoma, Seattle
- Shoreline -- Connecticut

Gravity Model

Transportation professionals typically apply a number of sophisticated computer models to forecast travel movement and volume. These models work best when a number of basic variables are known, for instance, the potential audience for the travel, the trip purpose, family income and competitive travel time and cost (comparing personal vehicle to transit travel time). In this case, because the high speed rail is a new concept and is sometimes compared to the airlines, the traditional ground models may be problematic. Increasing the understanding of connecting ultimate origins and destinations to the terminal location near I10 and Old Katy Road led to a more historical approach. To gain a perspective of the potential for key locations in Houston to attract HSR riders, a gravity based model was calculated. The gravity model predicts movement of people by taking into account potential size of attractors, distance and time of travel. The relative strength of the linkage between two points is shown by the following formula modified from Erlander and Stewart (1990):

$$T_{ij} = \frac{A_j F_{ij} K_{ij}}{\sum A_j F_{ij} K_{ij}} * P_i$$

In our study, variable definitions are shown in Table 1.

Table 1: Explanation of Variables

P	passengers/hour	Trip production from HSR station
j	Destination	Destination Zip Code
T	$T_j = A_j * F_j * K_j$	Trip distribution index
A	Employment density: Employment/Area	Zone attraction factor
F	Travel time peak and off peak	Travel time factor
K	Median household income	Social factor

4. FINDINGS

Survey Findings

In order to better understand egress from existing intercity rail systems, 20 agencies shown in the methodology section were forwarded survey instruments. Modes anticipated included transit, person vehicles, and rental options. Of the agencies queried, 6 respondents completed the survey. Responses are described according to transit connections, egress by individual private vehicles, pedestrian accommodation, and bicycle connections.

Transit Connections (or shared ride egress): All 6 had connections to local bus systems. Three agencies had both light and rapid rail connections and one had rapid rail transit, as well. One agency's intercity rail connected with a commuter rail line. Of the agencies, one has 15 bus bays, 2 have 4 bays, 1 three bays and 1 with one bay. The survey asked whether special events resulted in ridership spikes or changes in required egress modes. Most indicated not, but one responded yes and additional buses were provided.

Individual Vehicles Egress: Five respondents had taxi zones and space for personal vehicle pick-up, including TNCs. Of those, 2 have 4 spaces and 2 have 5 spaces. Respondents indicated that the allocation of space for these modes is adequate.

Pedestrian Accommodations: Four of the six agencies answered questions about the pedestrian amenities. All indicated that the access to transit or personal vehicle pick-up was covered, lighted and easily walkable. The pathways were attached to the terminal structure requiring no exposure to the elements.

Bicycle Connections: The six respondents had bicycle provisions at the terminal and 5 noted accommodations for bicycles on the trains. When asked whether bicycle accommodations were sufficient, one respondent indicated no.

Airport Select Modal Egress: Table 2 shows the dominance of taxis and secondarily, TNCs (service by Uber at Houston airports), in the personal trip categories. Trips 1 and 2 for taxis and TNCs represent time allocations and add to the total. Limousines represented a small portion and Super Shuttle, while not in the table, reported 15 trips. Trip length is not provided, but both airports are distant from the central and employment areas of the city. The high speed rail patrons will likely be prone to taxi use. Taxi trips are more than double trips by TNCs.

Table 2: Taxi, TNC and Limousine Usage from Houston Airports

	Jan 2016		Dec 2015	Nov. 2015	Oct. 2015
Taxi Trip 1	31137		28956	34308	41068
Taxi Trip 2	30058		29619	36179	41068
Taxi Trip Total	61195		58575	70487	82136
Avg. Passenger per trip	1.2		1.2	1.2	1.2
Uber - Permits 1	20,314		20,947	20,742	16,550
Uber - Permits 2	644		645	594	625
Uber Trip Total	20,958		21,592	21,336	17,175
Occasional use permits	315		389	544	459
Limos permits	385		302	209	216
Limos and Others Trips Total	700		691	753	675

Gravity Equation

An important component of the project focused on relative attraction of the major activity center to the IH-10/Old Katy Road terminal location and the potential for HSR riders to take transit or another conveyance. Gravity model equation was used to assess the potential of select activity centers to attract riders by mode based on the peak and non-peak travel times, the employment numbers and household incomes of residents. The team prepared a trip distribution index reflecting the results of the gravity equation.

The gravity model applies values reflecting peak and non-peak hour travel time; the attractiveness of the location called the zone attraction factor is the employment density, and the social factor is interpreted by the median household income. The lower the number on the Gravity Trip Distribution Index, the more competitive will be the transit option. Table 3 shows downtown and Uptown with similarly favorable index values. Westchase and the Energy Corridor follow, and the Woodlands has a large index, showing a long travel distance, low density and fairly high income. The table includes the time to take a transit vehicle to the named activity center.

Table 3: Summary of Gravity Index, Transit Travel Time and Distribution Options

Employment Center	Gravity Trip Distribution Index	Transit Travel Time at 8:05 a.m. Weekday (minutes)	Transit Competitive **(+,0,-)**	Travel Options
Downtown	25.31	25	**+**	**Transit, the Wave, TNC, Taxi,** Rental Car
Uptown	23.31	24	**+**	**Transit, the Wave, TNC, Taxi,** Rental Car
Westchase District	31.23	55	**0**	Transit, **TNC, Taxi, Rental Car**
Energy Corridor	31.56	59	**0**	Transit, **TNC, Taxi, Rental Car**
Woodlands	178.75	Not Available	--	TNC, Taxi **Rental Car**

Key: Transit is likely (green, +), Transit is possible, but less likely than green (buff and 0), transit is unlikely (gray, --). Strong travel options are shown in bold black, and secondary option in gray.

People exiting the high speed rail vehicles will be destined throughout the region. Their decision about the mode will depend on the travel time, parking space availability and cost and duration of stay. Five locations are identified to calculate the gravity distribution index. A transit choice increases if the travel time is competitive. When travel time is competitive, transit, taxi, the Wave and TNC are likely options. Decisions may vary if users' are staying more than overnight; acquiring a car may be more likely if the trip duration is multiple days. Downtown and Uptown have competitive transit travel times based on today's METRO System. METRO transit system improvements to those two locations that provide exclusive transit options would improve transit speeds, and in some cases may be shorter than in a personal vehicle.
The table shows that transit is most competitive for Downtown and Uptown, less likely for Westchase and the Energy Corridor, and unlikely for the Woodlands. Other vehicle options are most likely due to the distance from the terminal location.

5. SUMMARY OF FINDINGS

This work examined the options for connectivity. Findings from this work are designed to assist in guiding area officials in beginning to assess physical needs, such as vehicle bays, rental facilities, passenger pick-up areas to meet the anticipated disbursement of TC passengers and provide information for public and private transportation entities to anticipate how they might prepare for interregional rail and interconnectivity with their operation. While there are no direct comparisons from other US cities with intercity rail or the Houston airports, the work allows several general thoughts.

- Transit users will likely be destined to Uptown and Downtown, particularly so as those connections are anticipated to be improved with the implementation of high speed rail. In fact, the transit travel time in future years may be better than personal vehicle travel time to these two locations.
- High speed rail patrons destined to other activity centers may choose transit, but are less likely to do so than those destined to Uptown and Downtown.
- High speed rail patrons destined to non-activity centers are most likely to use TNCs, other personal vehicle modes, or rental car.
- Taxi will likely be a prominent choice and should be well-accommodated.
- It is important to ensure covered, protected pedestrian amenities for all connections.
- Bicycle accommodations should be provided.

As more information is known about the users of the high speed rail, additional research could more specifically examine the magnitude of distribution to the activity/employment centers and provide greater insight into bay location and sizing.

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APPENDIX

ACE – Stockton to San Jose, California
UTA – Utah
Coaster – San Diego, California
TRE – Ft. Worth, Texas
METRA – Northeastern Illinois
NICTD – Chicago, Michigan City, Illinois
RTA – Chicago area
METROlink – Southern California
NM Rail Runner – Santa Fe to Belen, NM
Northstar – Minneapolis to St. Paul, Minnesota
Metro-North/Long Island RR
SEPTA – Southeastern Pennsylvania
MARC – Baltimore to Washington, DC
VRE – Virginia Railway Express
MBTA – Boston, MA
NJ Transit – New Jersey Transit
Tri Rail – Miami to Ft. Lauderdale, FL
Caltrains – San Francisco, Menlo Park to San Jose
Sounder – Lakewood, Tacoma, Seattle
Shoreline -- Connecticut